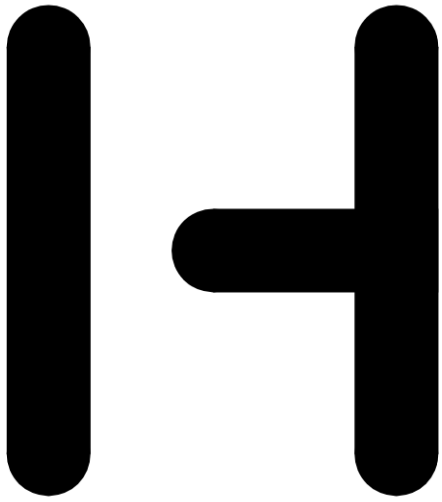
HADRON

December 2021

IMSA Scientific Periodical



HADRON

AN IMSA EDITORIAL

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Contents

ALTERNATIVES TO TRANSPLANTATION: PIG ORGANS AND MECHANICAL HEARTS

By Jack Morby

Thousands of people are living with a severe cardiological issue and are waiting for a heart to be donated. Often, these people never receive a transplant operation and die waiting. Because of the large need for healthy donated organs, researchers have been working hard to come up with alternatives. An overwhelming amount of unique processes have been invented to address this problem, ranging from xenotransplantation to mechanical hearts. Researchers trying to solve the organ transplant shortage not only face a technological challenge but also an ethical debate. The novel operations like receiving a mechanical heart are not always safe, and there is sometimes considerable risk involved. Each method of heart transplant has varying potential for improving the condition of humankind, which makes them all worth pursuing and understanding further.

The process of "xenotransplantation," transplanting organs from animals into human bodies, is not a new concept. The transplantation has been practiced for the past century with optimistic results. Many independent experiments included the transplantation of organs from various species such as pigs, chimpanzees, and baboons. But, one of the largest problems with transplanting foreign matter into the human body is the reaction that could ensue. If the human immune system recognizes the new organ as foreign matter, it would target it with T-cells and antibodies which would cause damage. Most operations might be successful in the hours or days that follow the surgery, but is not effective in the long-term. This response poses a significant obstacle to the field. Luckily, because of genetic engineering and other methods, work is being done to overcome this response and trick the body into thinking the organ is not foreign material. As shown in the figure below, research in the field is not always done with humans because of the risks associated with the experimental nature of the operation. As an alternative, non-human primates are commonly used. Figure 1 is based on transplants of pig organs into non-human primates. The study was done to test the immune response of the primates and therefore gain better knowledge of a human's immune response because of the similarity in physiology between primates.

Xenograft	Donor pigs genetic background	Immunosuppressive therapy	Survival time (day)	Year (Reference)	Initial survival time (donor pig)
Heart (non-life supporting)	GTKO/CD46/TBM	ATG, anti-CD40mAb, anti-CD20mAb, MMF, CVF, Solu-Medrol, aspirin, heparin, Ganciclovir, Cefazolin, Epogen	Rang from 159 to **945** Median: 298 days $n = 5$	(145)	6 h (WT)
Heart (life supporting)	GTKO/CD46/TBM	Anti-CD20mAb, ATG, anti-CD40mAb, MMF, methylpednisolone, temsirolimus, steroid cortisone	18, 27, 40, **195** $n = 5$	(161)	9 days (hCD55)
Kidney (life supporting)	GTKO/CD55	Anti-CD154 mAb, MMF, solumedrol	**499**, 414, >70 $n = 3$	(162)	13 days (WT)
Lung	GTKO/CD47/CD55	ATG, rituximab, anti-CD154 mAb and mycophenolate mofetil	**14**, 13, 4, 2, 1 $n = 5$	(163)	11 h (WT)
Liver	GTKO	ATG, anti-CD40mAb, tracrolimus, Cs, CVF, hPCC	25, **29** $n = 2$	(164)	84 h (WT)

ATG, antithymocyte globulin; MMF, mycophenolate mofetil; CVF, cobra venom factor; hPCC, human prothrombin complex concentrate.
Bold values represent the longest survival time of xenograft.

Figure 1

A table depicting the best survival time of solid organ xenotransplantation from pigs to non-human primates.

Source: *Lu, Tianyu*

Another alternative that is being researched and utilized is a mechanical version of the heart, which is able to complete all of a heart's functions. One of the most commonly used versions of the mechanical heart is the SynCardia Total Artificial Heart. Over 600 patients have been transplanted with SynCardia since 2010. This device is made of biocompatible plastic so as to avoid the immune response and is composed of two ventricles and four valves. It pumps blood by sending pulses of air to inflate the machine and push blood through your body and then also send pulses of vacuum to suck it in as well. A battery powered external driver can be worn in a purse-like bag to even be mobile with the device. The downside to this device is that it can only be used as a "bridge transplant" with the sole purpose of extending the patient's life until they can transplant an actual human heart. However, despite not being the complete answer, it still is a massive step towards solving the problem.

Besides the SynCardia, there has also been research into machines that assist the existing heart in its functions instead of replacing it to prolong its effective lifespan. Shown in the figure below is one of these devices called a "cardiac sling." The device applies pressure to the heart at the correct times by following the rhythm of the heart to help with the pumping of blood.

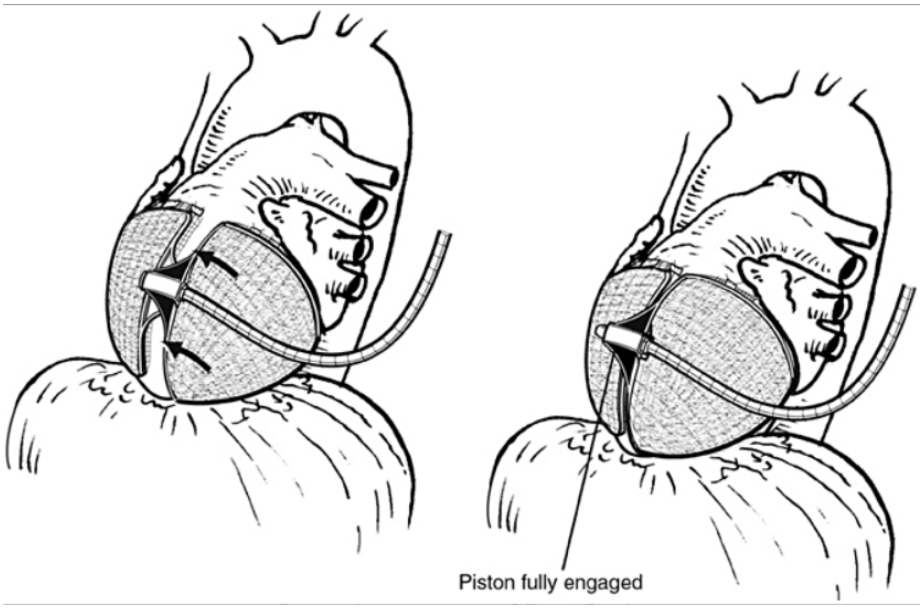


Figure 2: Drawing of a hypothetical "cardiac sling" powered by the MEC. On the left side of the figure, the wrap is allowed to open up as the ventricles fill. On the right, the MEC actuates a piston that closes the wrap around the heart, preferentially pulling the left wall.

Source: *Trumble, Dennis*

Because it is just building off of the scaffolding of the natural organ it is much less intrusive compared to removing the organ and helps to decrease the chances of the body rejecting the device.

The advancements that will be made in the field of biomedical engineering have and will continue to change the future of medicine. The health-care industry is always finding new problems that need to be solved, often needing innovative solutions. As more people realize the potential of fascinating solutions like xenotransplantation and mechanical hearts, especially as they advance to being a long-term solution, more investments will be made into this technology and the probability of its success will increase. Serious attention to this field can lead to new heart-transplant methods that will help save thousands of lives.

HUMAN-INDUCED CLIMATE CHANGE LEADS TO INCREASED WILDFIRES IN THE UNITED STATES

By Kaylee Zhou

Wildfires are fires that are uncontrolled and often damage rural environments and ecosystems (National Geographic Society, 2019). Usually, wildfires occur above ground, but recently there have been many wildfires that happen both above and cause damage to the top layer of soil. Wildfires are dangerous because of their ability to quickly spread and decrease air quality. The West Coast of the United States is notorious for their annual wildfires. In particular, the state of California has suffered many long and damaging wildfires in recent years. Scientists from the University of California at Los Angeles and the Lawrence Livermore National Laboratory have collaborated to research how climate change has affected the wildfire patterns over the past twenty years. They concluded that human-induced climate change has been the main cause of increased wildfires in the United States (ScienceDaily, 2021).

How was this discovered?

University of California at Los Angeles professor, Rong Fu, led the team's research study, starting by examining the United States' Geological Survey data. He compared the increase in area burned for 11 states in the West overtime. From 1984 to 2000, an average of 1.69 million acres burned per year, but from 2001 to 2018, the average acres burned per year increased to 3.35 million. More recently, the National Interagency Coordination Center reported that in 2020, 8.8 million acres burned due to wildfires.

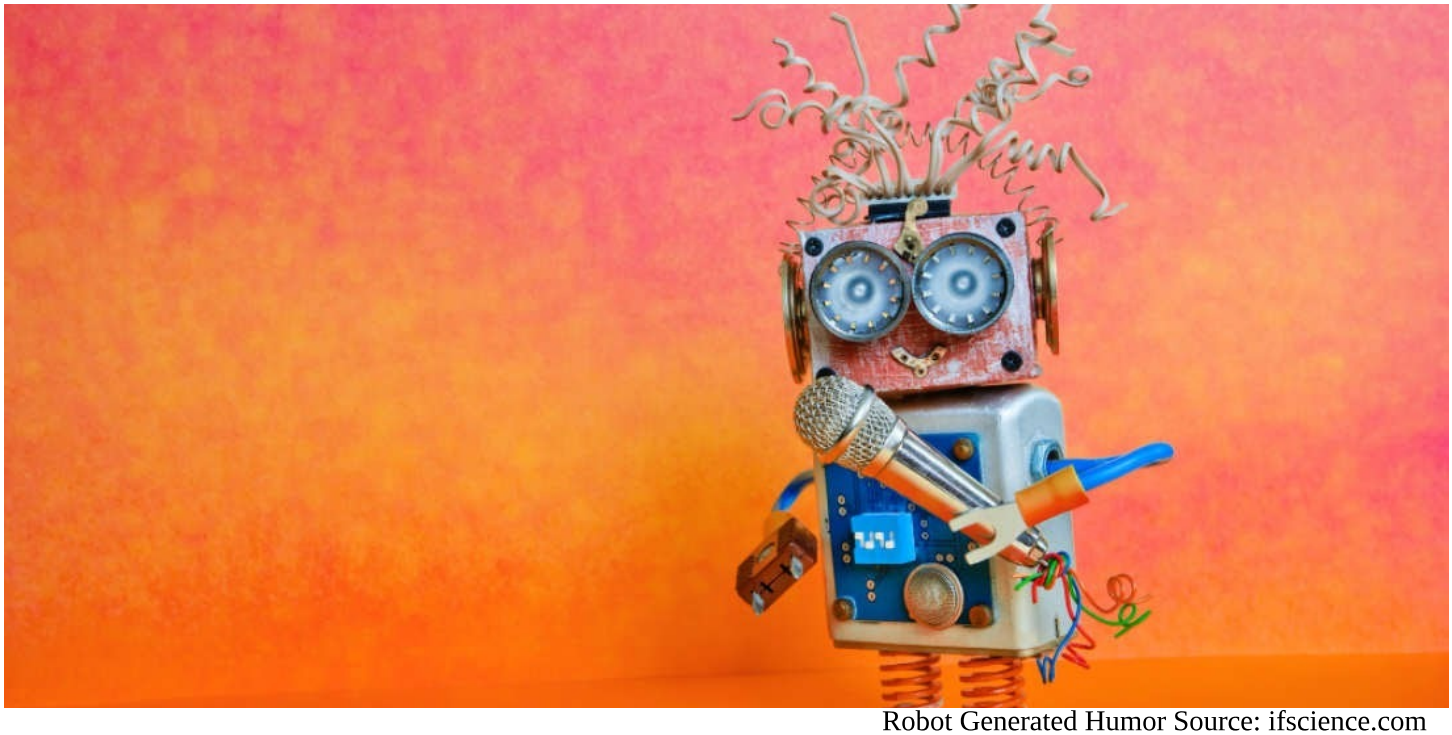
These statistical points shocked scientists, and they were eager to learn how much of these wildfires were caused by human-induced climate change, rather than natural changes in weather patterns. To continue their research, they turned to Artificial Intelligence. Using this tool, the researchers estimated how much climate change and other factors led to wildfire risk. This estimation was measured through vapor pressure deficit.

What is vapor pressure deficit?

Vapor pressure deficit is a unit of measurement that tells the difference between the amount of pressure in an air's water and its saturation point. The saturation point is the maximum amount of pressure the air can carry at its given temperature (Drygair Greenhouse Dehumidifiers, 2021). This unit of measure is important because it provides information about the temperature of the air and how humid an area is. These two factors are both important for learning about wildfires in certain areas. The higher the vapor pressure deficit, the drier an area is, leading to increased chances for wildfires. Professor Park Williams from Columbia University pointed out that the vapor pressure deficit for California reached its all-time high in August 2020. This information showcases the correlation between vapor pressure deficit data and wildfires, since that time period also led to large, uncontrollable wildfires across California (Meyer, 2020). At the conclusion of his study, Fu's research results indicated that from 1979 to 2020, 68% of the vapor pressure deficit increase in the United States resulted from human-induced global warming.

Conclusion

Rong Fu believes that this research was beneficial for allowing scientists to understand that wildfires will progressively become more intense and more frequent in the future. In fact, he said, "Our results suggest that the western United States appears to have passed a critical threshold -- human-induced warming is now more responsible for the increase of vapor pressure deficit than natural variations in atmospheric circulation" (ScienceDaily, 2021). Overall, Fu tried to express that humans have caused much damage over the decades, but he never expected this damage to impact society so much, so quickly. The researchers initially thought that these consequences would only occur decades and centuries later, but instead they occurred much earlier than expected. On a lighter note, the recognition of these environmental issues is the first step towards solving the problem.



Robot Generated Humor Source: ifscience.com

A.I. GENERATED HUMOR

By Avyay Duggirala

The use of artificial intelligence (A.I.) is rapidly increasing in a variety of different industries. A.I. is most commonly associated with jobs such as analyzing algorithms, sorting through big data, or doing a host of other important tasks. In actuality, however, A.I. can be applied to almost everything, even making jokes.

How Funny Is It?

The jokes made by these A.I. 's are better than, or as good as, than jokes that humans make. In order to confirm this, Harvard ran researchers conducted a series of experiments, in which they approached 1000 random people and told each of them a joke generated by A.I. and a joke created by a human. Shockingly, they found that people laughed at the jokes made by the A.I. approximately 4% more often than the jokes made by humans. This difference may be small, but it demonstrates the power and potential of A.I. The power of A.I. can be channeled in different ways as there are a variety of different joke telling A.I. and all of them work to a varying degree. These joke telling A.I. also tell these jokes in a variety of formats, from corny dad jokes to “Yo mama” jokes offering a way to make anyone with any sense of humor laugh.

The Logic of Jokes

Although it seems like writing jokes may require emotion, there is actually a logical way to create them. Most jokes have the core parts of the set-up and the punchline. In the set-up, as the name implies, you set up the joke and prepare it for the punchline. The punchline is what makes the joke funny, and it is often an unexpected retort or response. It could also be a misjudgment of the situation. Both of these things can be automated by utilizing an algorithm, which is what led to the building of various A.I. and algorithms.

How Was It Made?

All modern day A.I. use machine learning—the use of algorithms and data to solve problems—to solve whatever task they are given. In the case of humor, the A.I. is first given a variety of jokes that are considered funny. Using algorithms to manipulate this data, the A.I. figures out what makes the jokes funny, and is able to recreate these jokes and others like them, using similar set-ups and punchlines. The one problem with machine learning is we don't know how the machine determines things and is able to recreate it. In the example of humor, we don't know what the computer thinks makes the joke funny. We simply get the output of the program. With all machine learning, we give the A.I. input and receive and output, however we don't know what happens in between, as these programs go through so much data at an extremely fast rate, and it would be impossible for a human to do the same thing. Humans can however create an abstraction, or basic rundown, of what the program does.

How Does It Work?

Joe Toplyn, the creator of Witscript, explains the process. First, the program chooses a topic and an attention grabber from its database. Then, it creates a punchline, finds a bridge from the joke to the punchline, and delivers it. However, the A.I. doesn't do all of this by itself; it outsources different parts of this process to be handled by other existing algorithms. To test Witscript, Toplyn inputted 13 different topics into the algorithm. This resulted in a variety of different jokes, all humorous to him and those he asked.

The Future With A.I.

As Joe says, "A.I. and A.I. generated humor still has a long way to go and will eventually be applied to everything". Almost everything can be done faster and more efficiently with the use of A.I., and humor is just the start. Humor, something that is usually made by humans, can be easily made by A.I. showing its ability to possibly replace humans need to be funny. One day, A.I. might be able to write entire movies, shows and do so much more than humans can, in less time than humans can. A.I. is the future and humor is just one major stepping stone in its journey.

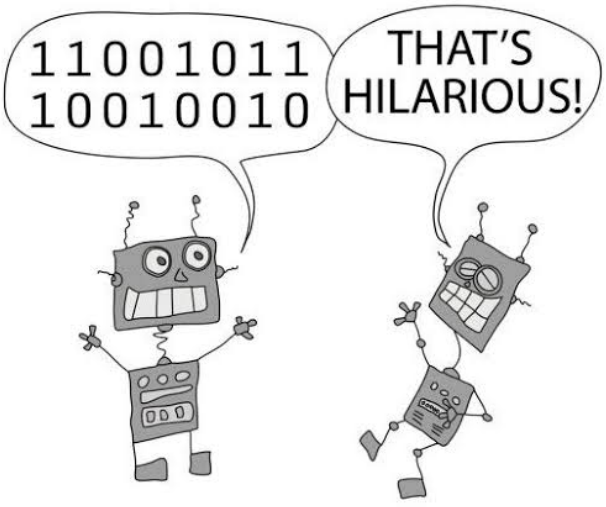


Figure 2

Graphic of Computers Telling Jokes

Source: Towards Data Science

An Image Used by Apple in Their Online Press Release Dated November 17, 2021 Source: Apple

FROM PROFESSIONAL EXCLUSIVE TO DIY: APPLE'S CHANGE IN STANCE ON REPAIRS

By Colin Ward

While Apple is famous for its innovation in technology, popular phones and computers, and sweeping innovation within the technology industry, it's also notorious for its flawed repair policy. Historically, they have been extremely opposed to the idea of user-performed repairs, going even so far as to design their phones to make it more difficult for someone lacking the specific tools, equipment, and experience to perform a repair. Starting next year, this is all supposed to change.

The Old

Prior to their unanticipated decision, Apple had restricted who could perform repairs, allowing only approved businesses and Apple locations to do so. On one hand, this may not have served as much of an inconvenience for the consumer, seeing as these businesses are not exactly uncommon, with names like Sprint, T-Mobile, and Verizon being among the list of over 2800 independent service providers. But on the other hand, these repairs did tend to be rather expensive.

The New

With the implementation of their new policy, Apple will begin selling parts and tools for the two most recent iPhones, allowing consumers to perform their own repairs, provided they can read and understand the manual. All parts and tools will be available on Apple's Self Service Repair Online Store. Here, more than 200 parts and tools can be purchased, allowing customers to repair some of the most common issues with the iPhone 12 and 13. While Apple recommends that only consumers with experience in electronics repair take advantage of this initiative, they are permitting devices with started, or even botched repairs to be brought in to authorized repair shops to be fixed, meaning just about anyone can give it a shot, but not all should. The icing on the

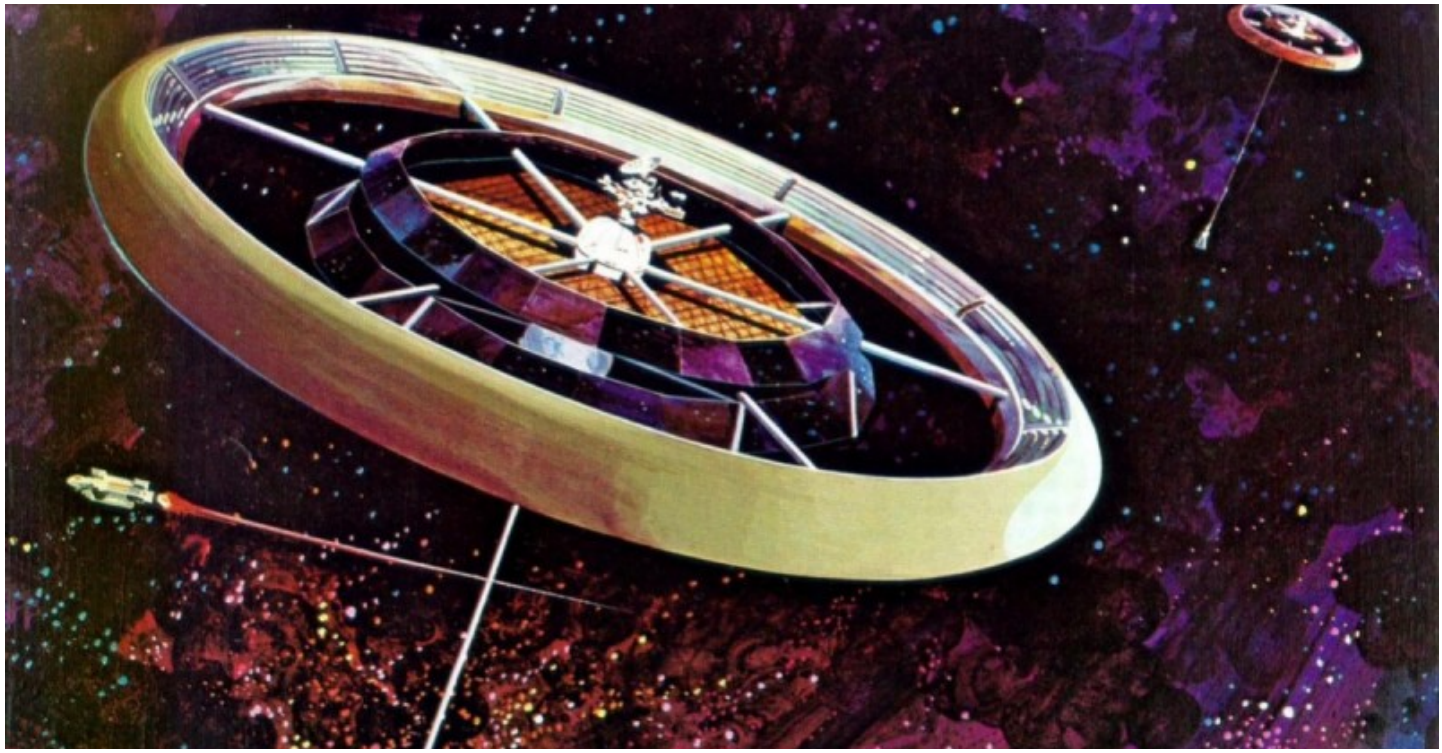
proverbial cake is the fact that self-service repairs will not void the warranty on an Apple product, even further reducing the risk involved in performing a self-repair.

Why?

The odds are, Apple has committed to this policy to avoid being mandated into adopting something similar by legislation. The Federal Trade Commission (FTC) released a report discussing the ethics of companies refusing to permit consumers to repair their products. The US Copyright Office also acted to allow certain exemptions to the DMCA, meaning consumers can do whatever they want with a device as long as it doesn't violate the copyright of the manufacturer. Just months after the release of the FTC report, and the actions of the Copyright Office, Apple revealed this policy, likely not by coincidence.

Apple will now be competing with websites like iFixit, which have been selling aftermarket Apple parts and manuals for years. Apple will be essentially providing the exact same service, but with the Apple logo and the trust placed therein. Given the prices for Apple replacement parts and services for these at approved Apple repair locations, it is likely that the parts being sold online will be significantly cheaper, potentially even as reasonable as some of the current third-party sites selling certain parts at an over 25% decrease in price. It is undoubtedly true that Apple was making a significant sum of money off of their old policy, which would force users to go to an Apple store, thereby supplying the said store with business, or the user would have to purchase a new device entirely.

Apple's recent change in stance is certainly surprising. The complete turnaround on an idea that they were famous in the industry for potentially shows a new, more lenient side of Apple, one that we all can look forward to seeing more of. While this policy might not be optimal for all Apple consumers, it is still something to keep an eye on.



THE ETHICS OF SPACE EXPLORATION/COLONIZATION

By Nandana Varma

On July 20, 2021, Jeff Bezos took to the stars as he flew in his company's rocket, riding his very own spacecraft. Another billionaire, Richard Branson, went up in his own rocket not even a week before. The commercial space industry has garnered an incredible amount of interest in recent years with the creation of private companies such as SpaceX and Virgin Galactic that are willing to send humans into space. As countless companies attempt to take command of this growing market, we must take the possible consequences of space exploration or even colonization into consideration. We, as humans, are naturally curious about worlds beyond our own, but in exploring those worlds, we ought to be conscious of the ethical repercussions.

Contamination

Human activities are what will eventually cause the Earth to become uninhabitable in the future. Similarly, when traveling to space, we must be concerned about our devastating environmental impacts on the ecosystems of other planets. For example, minerals on Mars could be exceptionally developed, but the consequences of mining on Earth are clearly seen with drastically changing habitats and climate change. Is it ethical for us to utilize these otherworldly resources but cause harm and contaminate these pristine areas?

Exploitation

Exploitation and exploration have always gone hand in hand throughout human history. Commodities such as sugar, oil, and spices have been great propellers of exploration on Earth, yet we have seen human exploitation run rampant when trying to acquire such resources. Exploitation of natural resources has also caused numerous problems including pollution,

climate change, and destruction of ecosystems/habitats. History has shown us the consequences of exploration, so should we allow these same mistakes to repeat themselves away from Earth?

Colonization

A major ethical concern regarding space colonization is its inherent elitist qualities. The main support for multi-planetary habitation comes from billionaires such as Elon Musk, Jeff Bezos, and others privileged with the resources to support space colonization. However, how could the average person afford to live on another planet? We need to realize that leaving to go live on another planet is not a viable option for billions of people on the planet. It is up to us to consider if it is ethical to leave them on a dying planet simply because they cannot afford a ticket to space.

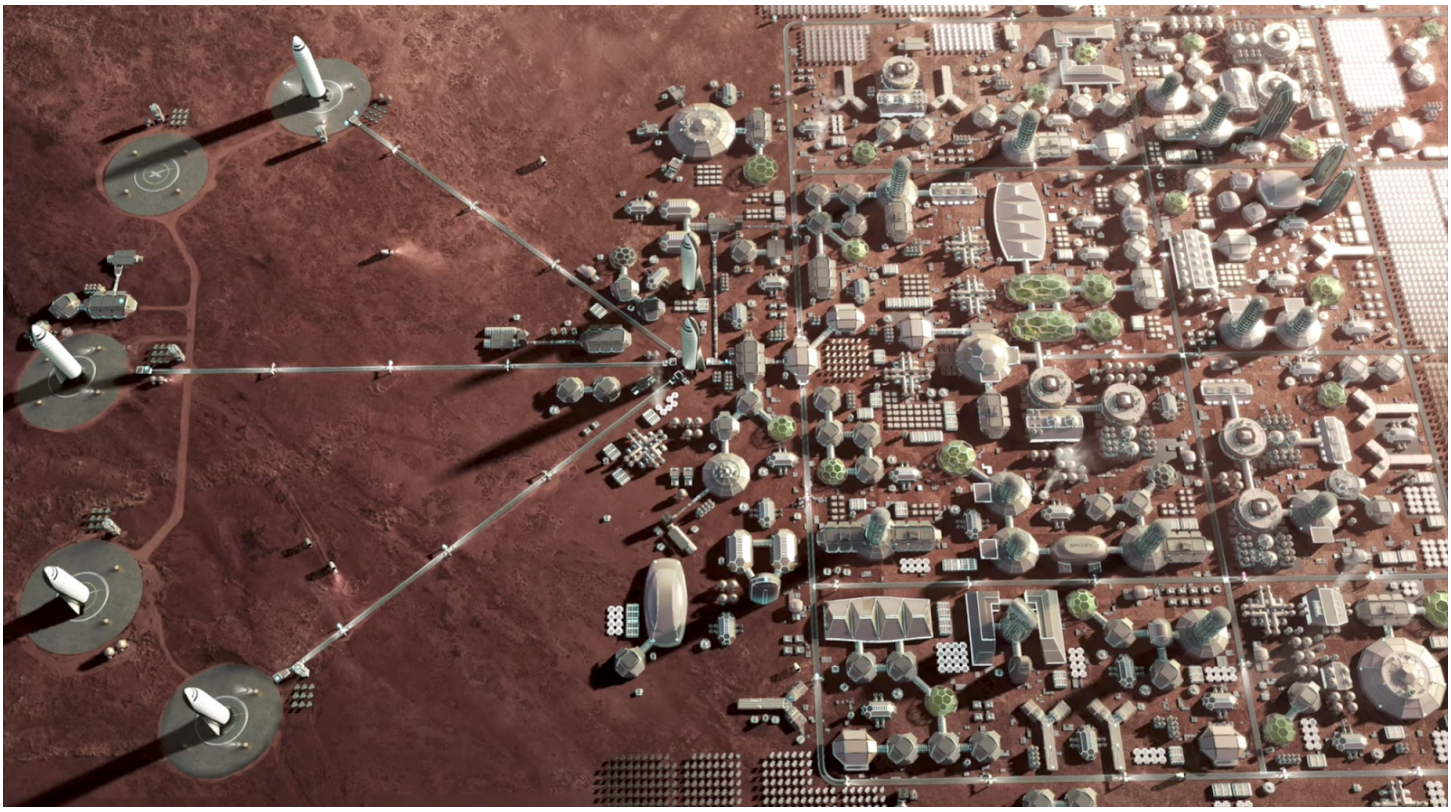
Ownership

With colonization also comes the issue of ownership: how do we decide who owns another world? Is it the country that reaches the land first? Does ownership belong to the countries with the resources to best colonize the planet? There are numerous questions that make ownership a very touchy subject when it comes to space colonization. Many major conflicts throughout history have been attributed to disputes over land ownership. These conflicts have led to the loss of land, resources, and life, so is it ethical to send humans to space and create these same conflicts and cause the same amounts of destruction?

Conclusion

As we are approaching this new age of space exploration, we are faced with difficult questions concerning ethics. We have to consider the issues of contamination, exploitation, colonization, and ownership, in addition to numerous other issues when deciding on space travel. As time moves on, perhaps we as a society can grow from our mistakes and ethically explore/colonize worlds beyond our reach.

An image of a plan for a colony on Mars



NFTS: IP RIGHTS OR SCAMS? AND AT WHAT COST?

By Gloria Wang

On November 18, Francis Bacon's painting *Pope with Owls* sold for $33 million. A week before, Van Gogh's *Cabanes de bois parmi les oliviers et cyprès (Wooden huts among olive and cypress trees)* sold for $71.3 million. While it isn't uncommon for paintings to sell for millions, a digital piece —visual artist Beeple's *Everydays: The First 5000 Days* —sold for $69M. But why would anyone spend nearly $70 million on a digital copy of an illustration that can easily be screenshotted for free? Buyers don't even receive a physical print to hang up in their living room. The reason for the price-tag is a non-fungible token (NFT): a unique electronic identification record stored on a blockchain used to establish ownership of an easily reproducible digital file.

Property in the Digital World

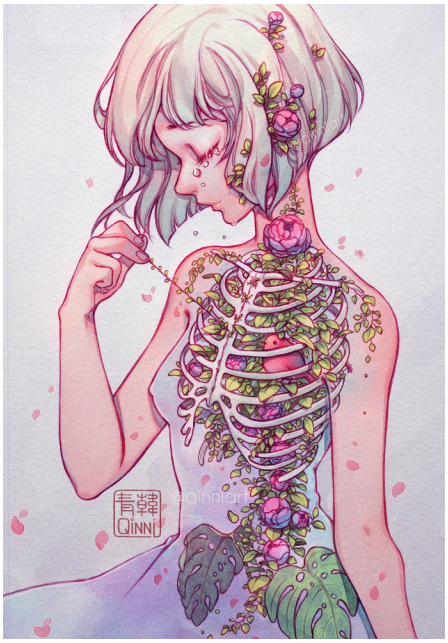
Before the invention of NFTs, there was no way to prove ownership of digital assets because it is nearly impossible to distinguish an original file from a digital copy. But without clearly defined ownership, transactions can't occur. If a million copies of a digital asset exist, it would be far less valuable than if there was only one, which is why NFTs are so special. Using NFTs, ownership history is embedded into the blockchain itself, authenticating ownership and differentiating between copies and the single, authentic file. In simpler terms, the NFT of a digital asset serves as the verified badge on social media platforms.

But how does this affect artists and other content creators? Traditionally, artists have a hard time protecting their intellectual property rights due to the difficulty of detecting, and thus regulating, art forgery. Even when works aren't forged, the collector of an artwork often profits more than the original artist by increasing the resale value. In order to claim a portion of those resale values, artists have pursued the *droit de suite*, or Artist's Resale Right, for over a century with limited success.

Few, like minimalist artist Sol LeWitt, are able to incorporate IP rights into the art itself. A Foreign Policy article describes how LeWitt's work "is not the wall drawing but rather a certificate… purchase[d] that grants them the right to install a specific wall drawing wherever they please. Transactions were policed by LeWitt's studio and are now regulated by his estate" (Greenwald 2021). Like LeWitt's certificate, a NFT serves as a permanent authenticator that can track all sales — including resales, which enables a kind of royalty contract where a percent of the resale price is transferred to the original artist.

Theft in NFT

Just like with physical property, the sale of a NFT doesn't automatically include the sale of copyright . Whether the copyright is transferred or not is up to the creator. Copyright ownership is valuable, providing "exclusive rights to the owner under 17 USC § 106 — the right to reproduce the work, prepare derivative works, distribute copies, to display the work publicly, and to perform the work publicly" (Chinlund & Gordon, 2021). Yet with the easily reproducible nature of digital files, individuals can easily offer works as NFTs without the artist's permission and even knowledge.



Birdcage, 2019. Digital illustration. A girl's heart, represented by a small bird, is held behind her ribcage as she stitches it back together.

Source: *Twitter, @QinniArt*

Digital illustrator Qing Han, best known as Qinni, was diagnosed with Stage 4 Fibrosis Sarcoma cancer on December 28, 2019. She died just months later. But only a year after her death, scammers started taking an interest in her works. Her brother, Ze, was informed that someone stole Qing's identity and started selling her works as NFTs. One of her pieces, titled *Birdcage*, was sold on the "first NFT marketplace" Twinci. Posted months before her death, the piece represents her struggles with heart disease which caused her to suffer through four open-heart surgeries. While the NFT was removed after Ze and Qing's Twitter fanbase reported the listing, the rise of NFTs has been followed by countless scammers profiting off artists' works. In a post on April 18, Ze tweeted, "'Please stop profiting off my dead sister'" (Han 2021).

Environmental Cost

Besides the questions of morality and authenticity, the billion dollar industry of NFTs poses a massive environmental cost to the planet. Ethereum mining — the blockchain most NFTs are based on — consumes about 26.5 terawatt-hours (TWh) of electricity per year, nearly equivalent to the 26 TWh consumed by the entire country of Ireland in 2017 (Somvichian-Clausen 2021). This is because Ethereum, like most major blockchains, is built on a "proof of work" system where "miners" solve complex puzzles to add verified transactions to the blockchain ledger. The intentionally inefficient system reduces incentives for individuals to mess up the ledger, but also requires a massive amount of computational power to run.

Ethereum's developers plan to shift to a less carbon-intensive form of security in 2022 via a blueprint called Ethereum 2.0 which uses a "proof of stake" — where users deposit some of their own cryptocurrency tokens into the blockchain as a "stake" instead of solving computationally intensive puzzles. This would "essentially mean that Ethereum's electricity consumption will… drop to almost zero," Michel Rauchs, a research affiliate at the Cambridge Centre for Alternative Finance, explains to The Verge (Calma 2021). But whether or not the shift will occur remains a question.

A more obvious solution to the environmental costs of NFTs is using clean energy. If blockchains start to run on renewable resources instead of fossil fuels, emissions will decrease drastically. But some experts, like de Vries, argued that "relying on renewable energy isn't a perfect solution for proof-of-work cryptocurrencies either. If mining for tokens continues to be extremely energy intensive, it will continue to put pressure on electricity grids and eat up renewable energy that could otherwise go toward something arguably more urgent — like heating or lighting homes" (Calma 2021).

Conclusion

As the future of blockchain technology remains uncertain, so does the potential impact these technologies have on Earth. While NFTs may provide a platform for digital artists and other creators to receive compensation for their work, it also provides a platform for scammers to profit off of others' work. Whether NFT platforms will be able to successfully help digital content creators receive proper payments for their work in an environment-friendly way remains unknown. But NFTs are likely here to stay.

CRYPTO: FUNCTIONALITY AND FUTURE

By Marco Ilic

Throughout the 2010s, cryptocurrency has risen from a fad to an increasingly adopted investment field totaling a $2 trillion market capitalization. The most prominent digital currency, otherwise known as coins, include the pioneer Bitcoin, with others like Ethereum, Cardano, Litecoin, and Dogecoin. Despite different underlying code, energy cost, and intended purpose, all coins share certain characteristics: they run on blockchain technology, use encryption to verify authenticity of assets, and are stored through digital wallets. The allure of crypto, another name for the bubbling currency, lies in its decentralized nature, as it provides a different mode of currency in opposition to central-bank controlled fiat money. Coins are not distributed through banks or reserves and are mined through energy costly hardware, ensuring that the value of stable-coins does not unproportionally decrease. With crypto's decentralized quality as the appeal for the asset, it raises a myriad of issues related to regulation, criminal activity, and financial independence.

History

While attempts to create digital currency throughout the late 20th century proved unsuccessful, they laid the groundwork for an independent virtual asset which had a value independent of conventional fiat currencies. In 2009, a pseudonym by the name of Satoshi Nakamoto described the prototype of blockchain technology and its subsequent currency, Bitcoin. The pseudonym, likely a team of programmers, created the coin later that year, where it experienced multiple system deficiencies, including a major 2010 hack involving 184 billion Bitcoin. As the coin saw its first years as an open currency, it constantly endured rigorous coding modifications and system changes, aimed at securing the safe passage of coins through transactions, wallet safety, and authentication through proof-of-work ledgers. In 2011, 10,000 Bitcoin was swapped in exchange for 2 pizzas, marking the first time in the coin's history that it is traded in return for globally acknowledged asset, the US dollar. As the coin gains traction through online forums like Reddit, in addition to the adoption of its value by various countries and companies, namely Microsoft in 2014 as a method of purchasing online games, competing coins like Litecoin and Ethereum emerged.

Appeal & Function

Cryptocurrencies' virtual nature allows owners to hold vast amounts of monetary value in digital wallets, databases where their value is stored and protected through encryption, which are specifically designed to protect from security breaches. The danger of physical money being counterfeit, lost, or destroyed is absent with cryptocurrency, as the blockchain uses proof-of-work ledgers which show how much energy has been expended on a certain coin, showing whether it is authentic and the amount of transactions incurred upon that coin. In addition, the coin's fluctuating value differs from other forms of digital currency like PayPal and CashApp, which use fiat, centrally-backed currencies as a third-party to determine the value. While crypto has an attached value to fiat currency, its value fluctuates with complete independence, typically with much higher volatility than conventional investments like stocks, bonds, and precious metals. As shown in figure 1, the historical patterns of Bitcoin show large, sudden spikes, typically followed by steep declines which produce new bases, with the pattern repeating with gradually more pronounced spikes and falls. As of November 2021, Bitcoin has risen over 10,600% since September 2011, with the price rising from $5.40 to over $60,000. The large risk attached to cryptocurrencies has compelled

many retail traders on mobile exchanges like Robinhood and Coinbase to trade in a highly risky, impauslive manner, a credit to the assets' largely meme-based culture. Meme-coins have evolved such as Shiba-inu and Dogecoin, which have experienced even greater volatility than 'stablecoins' like Ethereum and Bitcoin, which have historically followed safer patterns of price fluctuation. In October 2021, Shiba Inu, a rectnly created "memcoin" shot up 777% in merely 30 days, wheras Bitcoin rose 30% in the same timeframe.While many long-established investors like Charlie Munger and Ray Dalio call crypto "worthless", a new generation of prospective retail investors, in addition to many hedge funds, have taken increased notice and liking to the highly volatile, yet potentially fruitful asset.

Future

Many countries, namely China, India, and Iran, have already banned cryptocurrency, citing money laundering and tax evasion as major concerns. Despite widespread pushback, many countries are embracing the modern currency, albeit with regulations in place. Regulations governing cryptocurrencies will cover the safe handling of crypto through bank control, tax services, and the exchange of crypto for conventional fiat currency. While certain regulations have the ability to create the crypto market increasingly safe and efficient, many owners are offput with the idea of bank and government interference. The appeal for many crypto-enthusiasts initially was the complete independence in which the market operated, without influence from conventional currency. Regardless, specific regulation of cryptocurrency seems to be inevitable, as the exploding quantity of owners and ever-rising prices will continually grow the market, necesittating government outlines on how the asset will be approached. With government regulation looming, the risk of a crypto crash increases, as any major change in the way that cryptocurrency is handled will result in catastrophic price declines for the entire market. A crypto crash, which is a an extremely quick, and similarly drastic drop of value, can be incurred through investor uncertainty, regulatory woes, or black swan events - anything ranging from another pandemic to nuclear war.

Conclusion

Cryptocurrency's ever-growing market has its core values — a decentralized coin with little regulation on a collision course with the largest governments in the world, who seek to grow their control on the murky guidelines of the crypto market. Any large modification to the functionality and appeal of crypto could result in increased volatility, while creating an uncertain future for the direction of the relatively new currency. The way in which cryptocurrency will behave in the upcoming months and years will determine its long-term fate as a legitimate asset and investment.

Figure 1: Bitcoin All-Time Chart

Source: Investopedia

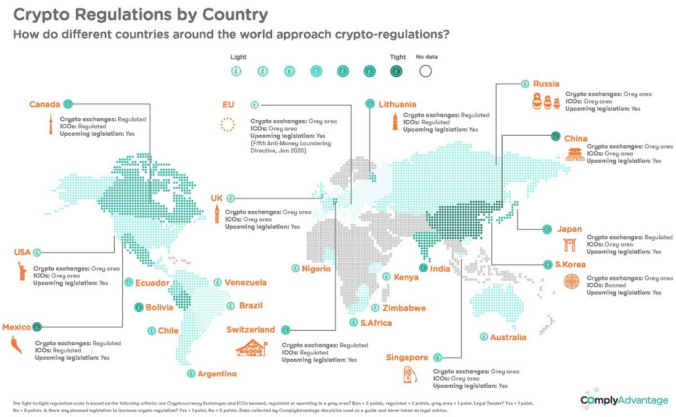


Figure 2: Various Regulatory Approaches by Countries

Source: *ComplyAdvantage*

SWIMMING NEAR THE EDGE: THE DECLINE OF THE VAQUITA

By Alek Simeunovic

Deep beneath the waves of the pacific ocean, two tiny porpoises speed past each other, communicating through a series of high-pitched whistles and clicks. They play with each other, spinning and doing tricks, as if they are dancing. These adorable animals are called Vaquitas (*Phocoena sinus)* and can only be found in a small portion of the eastern Pacific Ocean. This is the story behind this beautiful species and its tragic demise as it moves closer and closer to the brink of extinction.

Figure 1

The Gulf of California, also known as the Sea of Cortez, is one of the most biodiverse locations in the entire world.

Source: *undark.org*

A Biodiverse Treasure Trove

In the far western edge of Mexico lies the Sea of Cortez, a large inlet dotted with hundreds of islands. The sea's greatest surprise lies beneath its picturesque blue waves, which hides a plethora of biodiversity. This area is home to many of the world's most famous aquatic species, leading to it being dubbed as "The Aquarium of the World " by world-renowned explorer Jacques Cousteau. Due to the sea's temperature in that area, it is only able to support a large reef system in one spot close to its southern edge, which means that a large portion of the biodiversity comes from large vertebrates. Populations of plankton and squid form the bottom links of the massive food chain needed to support these creatures. Combined, these two factors make the Sea of Cortez one of the best places in the world for large aquatic animals to thrive.

What the Sea of Cortez is really known for is its cetaceans. This is an order of mammals that includes dolphins, whales, and porpoises. 33 out of 86 species of cetaceans currently recognized in the world can be found in this region of the world! The family also includes some of the largest creatures to call our planet home, such as the killer (*Orcinus orca*), humpback (*Megaptera novaeangliae*), and fin whales (*Balaenoptera physalus*), as well as their record-holding cousin; the blue whale (*Balaenoptera musculus*). While many cetaceans can reach truly impressive sizes, it is the smallest one that this story revolves around— the Vaquita.

A Shy Friend

Being the smallest living cetacean, the Vaquita weighs in at an average of 55 kilograms and grows from 1.4 meters long (males) to 1.5 meters long (females). Rather than eating tons of food like their cousins, their diet centers around small fish and squid. Vaquita are hunted individually as they are known to be solitary animals. However, if they are found in groups, they never number more than two to three, communicating through sonar in the same way as other cetaceans.

The Vaquita has a very specialized habitat, swimming no more than 25 kilometers from shore and staying in shallow lagoons up to 28 meters deep. Being the only type of porpoise living in such warm waters, the Vaquita has evolved to have very large dorsal fins. Scientists believe this is to allow the Vaquita's body heat to dissipate more efficiently. The higher abundance of predators has also helped them to evolve a unique color scheme that is dark grey on top, pale grey on the sides, and white on the bottom. Black markings around the lips make it look as if the Vaquita is always smiling. The famous black rings around the eyelids have led to the coining of their nickname; "Panda of the Sea."

Figure 2

A vaquita breaching the surface of the waves for some air. Since they are mammals, Vaquita need to breach about once every three minutes.

Source: *WWF.org*

The Beginning of the End

The tale of the decline of the Vaquita is quite long and begins across the world's largest ocean on an entirely separate continent. For centuries, wealthy Chinese citizens have craved *Fish Maw,* a delicacy made from the swim bladder of a specific fish. Totoaba (*Totoaba macdonaldi*), from whom the bladders come, use them to regulate buoyancy while swimming. The bladder has become incredibly valuable, fetching up to $46,000 for every kilogram sold. This has led many to pursue illegal poaching in order to reap profits, significantly harming the Totoba population.

Totoaba are very large fish, and Vaquita are very small cetaceans, ending up being a similar size to each other. Gillnet fishing, the primary method used by totoaba poachers, involves spreading long nets underwater in order to catch the fish while they are swimming. The mesh sizing of the net is meant for catching Totoaba, but helpless Vaquita also end up getting caught within the nets. Since they are mammals and require breaching the surface of the water for air, they drown within minutes of becoming entangled within the net. Sadly, this has been the primary cause of their population decline from 600 individuals in 1997 to a mere ten individuals in 2021.

Figure 3

A vaquita lying amidst a fishing net. Due to entanglement with fishing wires, vaquita populations dropped by over 90% between 2011 and 2016.

Source: *nytimes.org*

Hope on the Horizon

The plight of the Vaquita has not gone unnoticed by everyday civilians and governments alike. In an effort to re-establish Vaquita populations, the Mexican government put a 2-year complete ban on gillnet fishing in 2015, which was turned into a permanent ban in 2017. But, despite being compensated for income loss, fishermen continued to illegally use gillnets in the sea, contributing to even more decreases in the population. Both the Mexican government and scientific institutions have conducted surveys about the Vaquita population, using a combination of ship-based monitoring and sound-based detectors to capture the species distinct clicks and whistles.

Alongside the government's efforts, everyday citizens have also taken part in conservation efforts. People have written letters

signed petitions, sent donations, and boycotted certain seafood types, all in an effort to save our beloved tiny cetacean. In fact, a day in July every single year is dedicated to saving the Vaquita. On this day, people from around the world do what they can to help save the "Panda of the Sea."

What is one of the more creative approaches to this problem was conceived by none other than the United States Navy. The United States Navy Marine Mammal Program includes 75 dolphins and about 30 sea lions. These are trained for a multitude of tasks, such as minesweeping and finding missing scuba divers. Recently, the program has teamed up with the Mexican government to use its bottlenose dolphins as guides for the Vaquita, in order to find them and bring them to protected areas where they can be monitored as much as possible. While efforts like these show that there is still some hope, we were much too late.

A Lesson To Be Learned

Citizens and governments have banded together in an effort to save the Vaquita, which is an amazing thing, but the truth is that it may already be too late. With the population dropping to single digits, it may become impossible to bring the Vaquita back, but that does not mean we can't learn from our mistakes. We can organize ourselves to save our planet with the utmost urgency. By following the warning signs years in advance, we can prevent the fall of the Vaquita from repeating itself through other species in the future.

Figure 4

A Vaquita day celebration in Hong Kong. Celebrations take place around the world as people do their part in support of the smallest cetacean.

Source*: vivavaquita.org*

THE CHEMISTRY OF CARBON CAPTURE

By Dorrie Peters

In a world where climate change is one of the most pressing issues, scientists are constantly coming up with fresh solutions on how to save and preserve the planet. Some ideas, such as carbon capture, have been pulled from history. Carbon Capture and Storage, or CCS, is a technique of separating carbon dioxide from other gasses first implemented in the 1920s. Given that carbon dioxide emissions are one of the leading contributors to global warming, CCS has the potential to make an invaluable impact. In fact, successful CCS technology can trap around 90% of CO2 from its emission source. However, the technology's materials and risks make it difficult to execute. Noticing this, scientists have come up with new chemical solvents that could change CCS technology—and the climate crisis—as we know it.

How Does it Work?

Carbon capture has three main forms: post-combustion, pre-combustion, and oxyfuel combustion. All three methods work towards the same goal—to separate carbon dioxide from other gases—but each occurs at a different stage. Post-combustion is the most common and practical, as it can be built into factories and other sources of CO2 emissions. As the name implies, post-combustion CCS occurs after the burning of fossil fuels.

When burned for energy, fossil fuels create "flue gas", which is a combination of carbon dioxide, water vapor, nitrogen, sulfur dioxide, and dirt particles. Flue gases are extremely harmful to both human bodies and the environment and are one of the most common forms of air pollution.
Post-combustion CCS technology gathers the flue gas before it has a chance to enter the atmosphere.

Then, to accomplish the actual separation of CO2 from other gasses, a chemical solvent is employed. Certain chemical solvents have properties that absorb carbon dioxide while leaving other gasses untouched. The flue gas is exposed to these solvents in "absorption columns," resulting in a CO2-rich liquid and a more environmentally clean gas. Finally, the gas is released and the CO2 is transported via pipes into storage facilities underground.

Flaws

One outstanding flaw with the idea of carbon capture is the element of storage. Because there

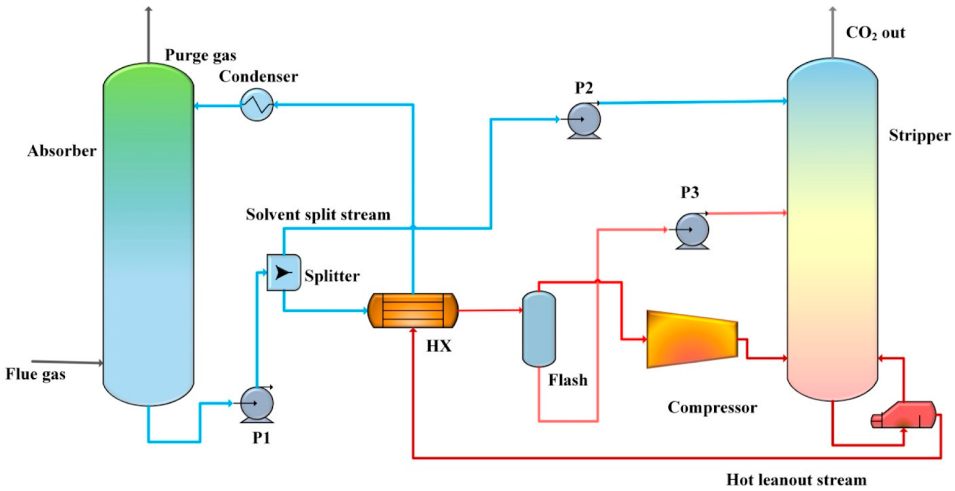


Figure 1

Model of the carbon absorption columns

Source: *Sustainability of Carbon Capture and Utilisation*

is no safe way to get rid of carbon dioxide completely, carbon capture technology resorts to storing the gas in holding areas far underground via a process called geological sequestration. While this does prevent CO2 from entering the atmosphere and damaging the ozone layer, it has other harmful effects on the environment. Storing such large amounts of carbon dioxide in the earth is foreseen to alter the acidity of soil and deplete certain nutrients in water.

Another flaw in carbon capturing lies in the solvents used during the absorption step of carbon capture. In this step, chemicals are used to soak up the carbon and remove it from the rest of the gas. Historically, the most common solvents used have been anime solvents such as monoethanolamine (MEA) and diglycolamine (DGA). These two chemicals are abundant in the carbon capture world mainly because of their low cost and high reactivity. However, amine solvents require very high amounts of energy and absorb at a medium/low rate. In other words, they are often inefficient and would be unsuitable if CCS was a widespread practice.

New discoveries

Because of the efficiency and efficacy flaws related to standard CCS solvents, professionals at the forefront of chemistry have created several alternatives. Among them are advanced amine solvents, amino acid salts, carbonate systems, aqueous ammonia, immiscible liquids, and ionic liquids. While these new solvents vary in price and availability, they are all working towards more efficient absorption.

Pacific Northwest National Laboratory is one example of a science institution at the forefront of carbon capture technology. Starting in the early 2010s, chemists such as David Heldebrant from PNNL have investigated the use of “water-lean” solvents, which have less H2O and more organic material than typical amine-based solvents. Because solvents with fewer water molecules have fewer bonds to be broken, they require less thermal energy to absorb carbon dioxide and are a better alternative for carbon capture processes

Conclusion

Given its high success rates and proximity to the largest factor of global warming, carbon capture has revolutionary potential in aiding the climate crisis. However, its efficacy must be improved if it is to function properly on a global scale. Problems related to the outdated and ineffective solvents used during the absorption process are being solved as new chemicals get tested to replace traditional amine compounds.

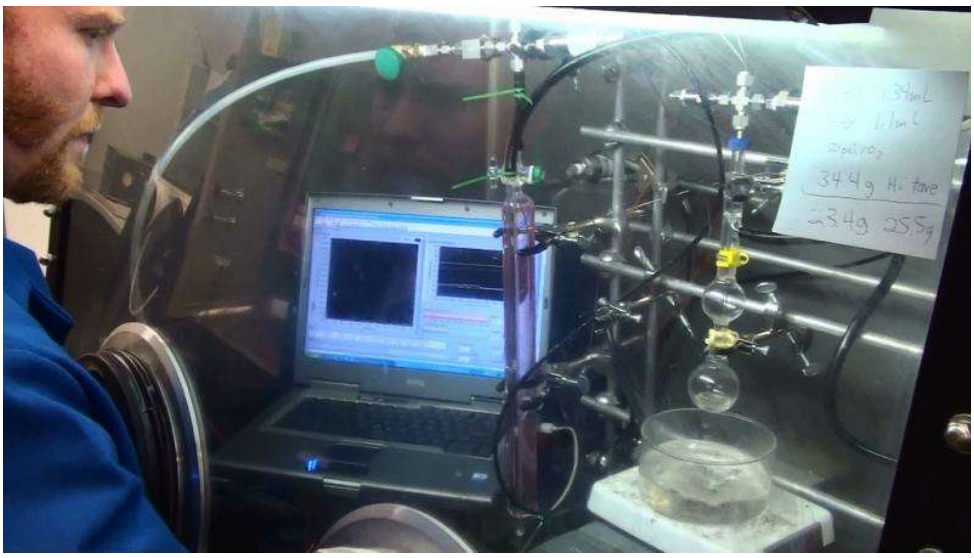


Figure 2

Scientist David Heldebrant tests new, more energy-efficient solvents Source: *Pacific Northwest National Laboratory*

Debunking Flatland: Space Filling Curves

By Gautham Anne

In 1877, George Cantor discovered that the number of points in a 2 dimensional plane is the same as the number of points in a 1 dimensional line. This is tremendously counterintuitive, since a plane can have an infinite number of lines placed 'side by side,' and stating that one line can pass through every other line seems absurd. Even Cantor himself wrote "I see it, but I don't believe it." This revelation is astounding and has many practical applications. This type of thinking revolutionized the way mathematicians have thought about dimensions and infinitesimal mathematical objects, and had transformed the realm of set theory forever.

Rigorous Definitions and More History

Cantor defined a one to one correspondence between the perimeter of a square and the points that lie within it. This means that every point that lies within the square can be mapped, or associated with, a point on the perimeter. This is a common methodology to prove that the cardinality, or the number of elements in a set, of two separate infinite sets are equal. If it can be shown that each element of one infinite set can be associated with exactly one element in another, then the number of elements of both sets must be the same. It is common to call this a bijection between two sets. Thus, sets with a bijective relationship have the same cardinality.

Soon after Cantor's discovery, a new question arose: "Is there a continuous mapping between a line and a 2 dimensional plane?" In other words, is it possible to trace a line that goes through every point in a plane without lifting the pencil once? After nearly a decade, many different types of such curves were discovered.

Filling Up a Plane with a Curve

There are multiple ways to solve the problem regarding the continuous mapping. For `example, two such 'go-to' solutions are depicted below, commonly referred to as the 'lawn mower solutions.'

Figure 1

Lawn Mower Solutions

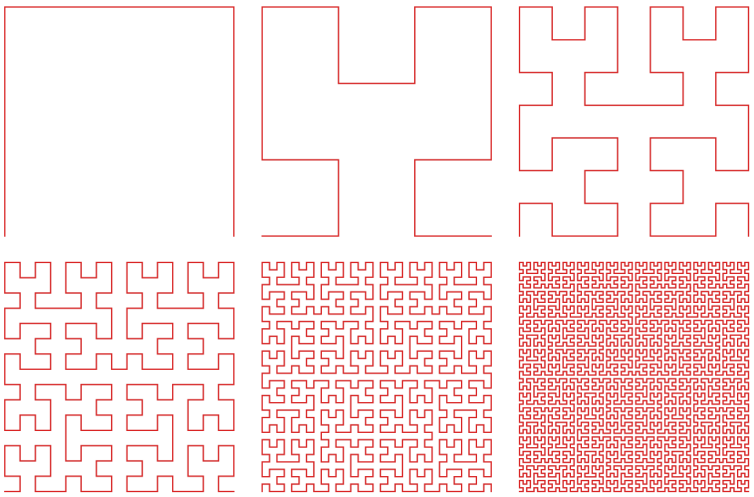
Source: *American Scientist*

In 1890, the first successful solution was described by Giuseppe Peano, who was an Italian mathematician also known for his famous Peano Axioms, the set of postulates that all of number theory is based upon. However, Peano did not describe the methodology of creating such a curve, but rather found a mathematical function that defines coordinates x and y given a point t on the line. David Hilbert, often regarded as one of the most influential mathematicians of the 20th century, devised a simple version of Peano's curve through a recursive, geometrical interpretation. Figure 2 shows the family of *Hilbert Curves*, through which each iteration, the curve gets closer and closer to reaching a completely filled square. In other words, the limit of the number of points that the curve does not pass through goes to 0 as the iterations increase to infinity.

Other Space Filling Curves

Although the Hilbert curve is one such mathematical procedure to impose a linear order of points in a 2 dimensional space (linearization), it is not the only one. Mathematicians have discovered numerous different curves which accomplish the same thing, yet have different

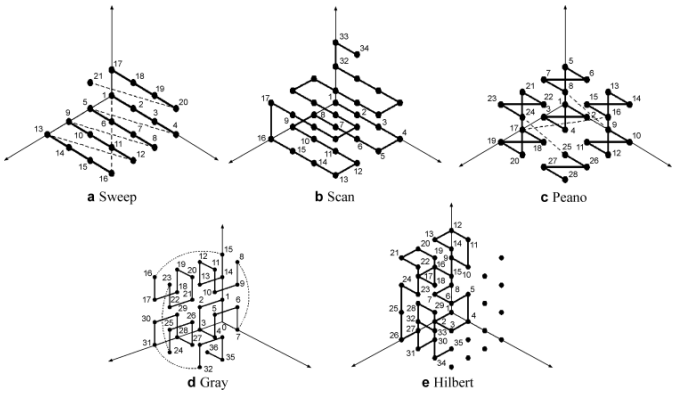
Figure 2



First 6 iterations of the Hilbert Curve

Source: *McGill University*

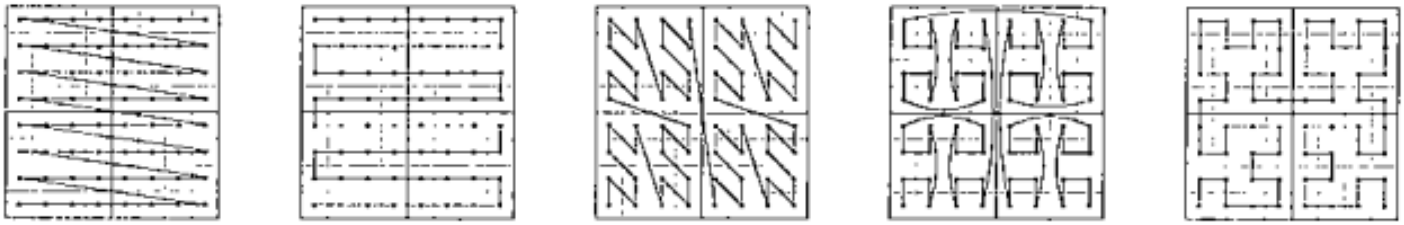
Figure 4



Different types of 3 dimensional space filling curve

Source: *Purdue University, University of Minnesota*

Figure 3



Different types of space filling curves Source: *Purdue University, University of Minnesota*

structures. These curves can be split into recursive space filling curves (RSFC) and non-recursive space filling curves (NRSFC). Looking at Figure 2, one can determine that each iteration of Hilbert Curves are fractals. That is, the previous iteration is repeated multiple times and joined together to form the next. This is precisely what an RSFC is. Each quadrant of a space RFSC is equivalent to the previous iteration of the curve. NRSFC do not recurse or possess fractal traits. Figure 3 shows some of the most common space filling curves.

Mathematicians have also generalized space filling curves to any dimension; any multidimensional space can be mapped onto a linear space, or a line. Figure 4 shows some of the common mappings of the 3 dimensional space onto a linear space at an nth iteration.

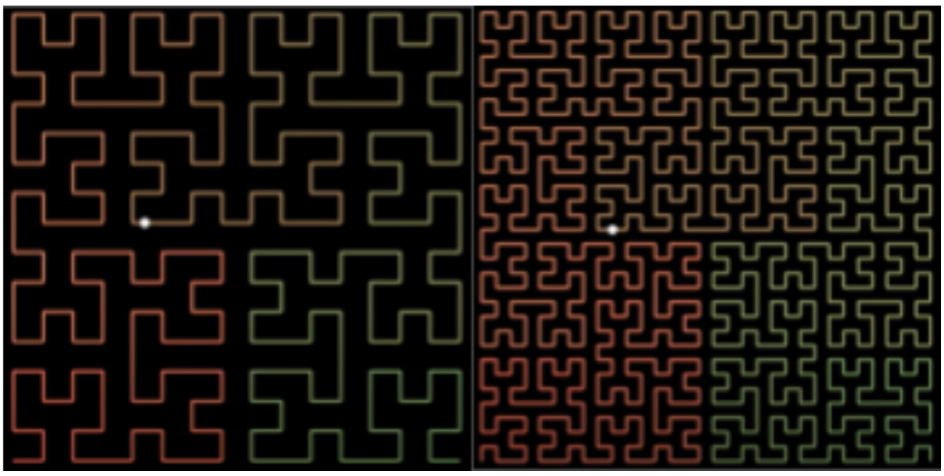
Locality

One interesting property of some space filling curves is that they preserve locality, which is when a point on the n dimensional space when iterated by a space filling curve does not 'move' in the space. The point's position is as close to being conserved as possible throughout the iterations. The classic Hilbert Curve has remarkable locality preserving properties, and Figure 5 demonstrates this in the 2 dimensional space.

Applications

Interestingly, many of the properties that space filling curves possess make them very useful for practical applications.

Figure 5



The location of the white point is very nearly preserved throughout the iteration process. This implies that the Hilbert Curve preserves locality very well.

Source: *3Blue1Brown*

One remarkable application of space filling curves was when a couple colleagues at the Georgia Institute of Technology aimed to find efficient routes to deliver meals to elderly clients scattered across Atlanta. This, in principle, is quite similar to the traveling salesman problem, which is notorious in computer science fields. Because some space filling curves preserve locality, a mapping across the streets of Atlanta could be approximated with such curves, providing a close to optimal path, even better than the one that can be predicted from the Bartholdi algorithm.

Another application of space filling curves is in the realm of linear algebra; specifically, the multiplication of matrices. For a computer to store or read rows and columns of matrices, some values may need to be accessed from the memory multiple times. In 2006, it was found that clustering the data of matrices with space filling curves can reduce memory traffic. Clustering is the process of mapping each cell in an matrix (or in general, an array) to a space filling curve, so the computer only has to store data on a single dimension, similar to how a plane can be mapped to a 1 dimensional line.

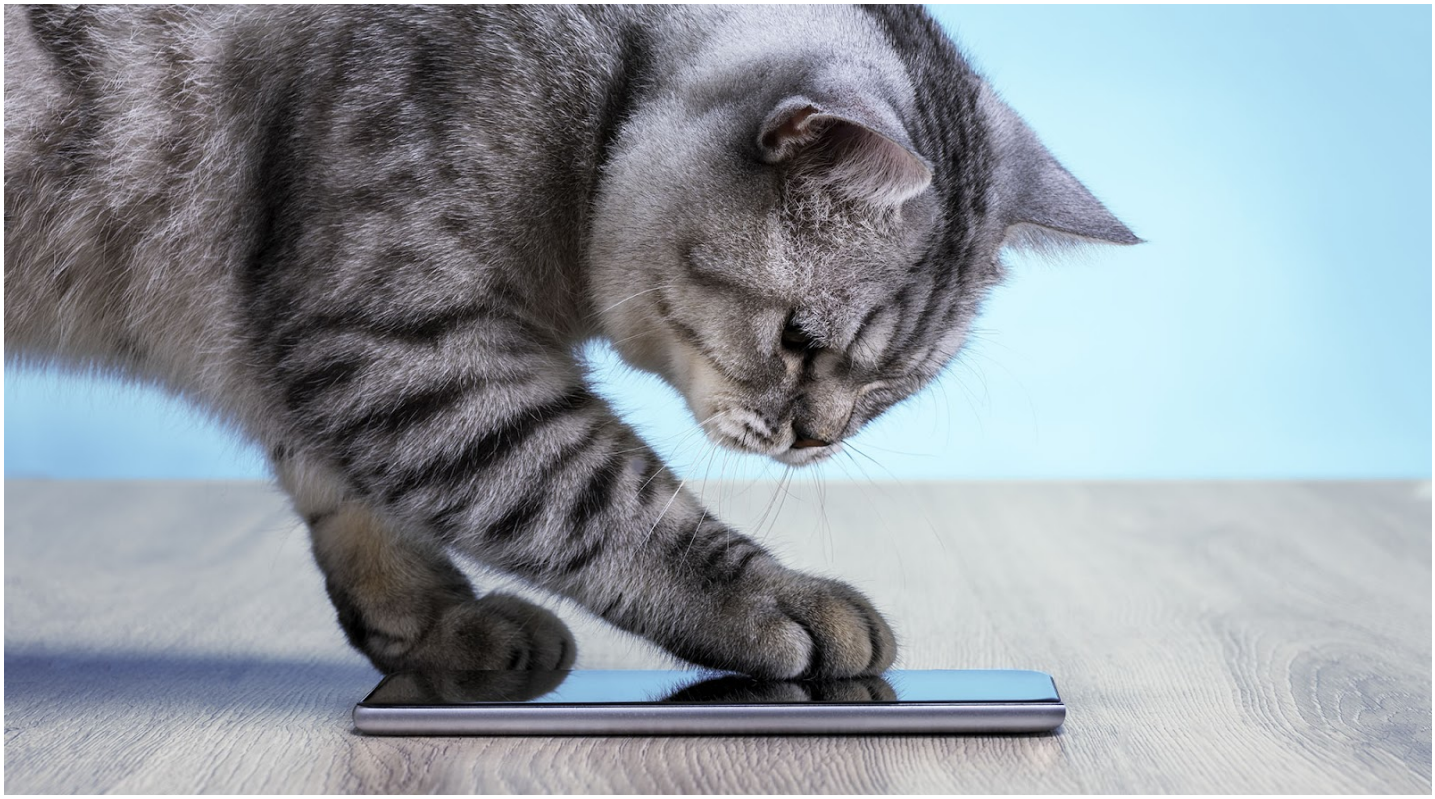
Laser printers have also enlisted the assistance of space filling curves for a process known as half-toning. Half-toning allows laser printers to produce tones of gray. Traditional half-toning uses an array of pixels that vary in size and darkness to produce grays. However, storing the pixels along the path of a Hilbert or Peano curve can help create smoother gradients of gray.

Finally, image processing heavily relies on space filling curves. Originally, each pixel in an image was stored in an array, which required a lot of memory. Later on, it was proposed that each pixel could be mapped onto a Hilbert curve, which would allow every pixel to be represented as a function, rather than an array, thus saving a lot of space. Another advantage of the use of space filling curves in image processing is that if the resolution of an image changes, the same curve, but a different iteration, can be used, since it preserves locality.

Conclusion

From the time of Descartes, it was thought that every point in a *d*-dimensional space must be represented in *d* coordinates. For example, in the xy plane, we use two coordinates. However, space filling curves propose a radically different way of representing multidimensional spaces. A single number can represent every single point, whether that point be in a line, plane, 3 dimensional solid, or even the 11 dimensional spaces that high energy physics involves.

In the novel *Flatland*, by Edwin Abbott, there exist creatures constrained to a one and two dimensional world that yearn to break free into higher dimensional spaces. In fact, they might be able to do so, by simply being a space filling curve.



Meow: 'Purrfecting' the Comprehension of Cat Communication

By Anisha Kolambe

While dogs are typically referred to as 'man's best friend', cats also have their own special significance in the history of human civilization. Revered by the ancient Egyptians, murdering a cat was equivalent to a death sentence, with further evidence of this respect corroborated by a cat cemetery in Beni-Hassan, complete with 300,000 cat mummies (Zax, 2007). The domestication of cats can be traced back to 12,000 years ago in the Near East, stemming from the Middle Eastern wildcat *Felis silvestris* (Zax, 2007). While dogs were productive in hunting down prey, the birth of the first agricultural societies warranted the need for cats in protecting surplus crops from rodents, initiating the mutualistic relationship between humans and their feline friends. Today, cats are one of the most popular household animals, with 373 million living as pets across the world (Mala, 2020). As society's fascination with cats continues to grow, so does the desire to understand the language of these animal friends, furthering advancements in the fields of behavior and technology.

The Meow Language

Ancestral cats lived alone, meaning that they rarely came in contact with other members of their species. This lack of correspondence resulted in the lack of vocal cues between cats, who instead relied on other methods of communication (primarily olfaction; the sense of smell) to reduce confrontation. These same principles still hold true for today's cats. Cats meow as kittens to indicate a state of need, such as food or warmth, to the parent safeguarding them (Whitcomb, 2020). However, by adulthood cats naturally outgrow this behavior. Feral cats, for instance, are more prone to use vocalizations such as hissing or growling rather than meowing. If a feral does meow, the action is

indiscriminate to the subject being a person, another animal, or inanimate object (Whitcomb, 2020). This observation indicates that cats are not naturally partial towards people.

In comparison to strays, house cats meow both more frequently and specifically at human beings, indicating that vocalization is a learned behavior stemming from domestication and environment. Since humans are unlikely to perceive and understand pheromones (the primary feline method of communication), cats have evolved to be more expressive in utilizing auditory messages to obtain their owner's attention. Through variations in tone and length of a meow to generate different meanings, cats have specially developed a language to converse with their human counterparts.

A cat meows as it waits for its owner to serve its food.

Source: *Stocksy*

A study with Maine Coon and European Shorthair cats was conducted by the University of Milan to determine whether consistent patterns were exhibited during meows. Furthermore, this study also aimed to test an AI framework's accuracy in classifying the context of these meows in three different settings: the wait for food, isolation in a new environment, and brushing (Ntalampiras et al., 2019). Bluetooth microphones were attached to cat collars to capture the spectral signature (a visualization of sound frequencies representing the distribution of energy over time) of the cat's vocalization. During data collection, the cats were subject to the various actions for a maximum of five minutes, with recordings taken during this time frame. The meow sound recordings were then isolated with preceding and ending segments of 0.5 seconds of silence. The final data set consisted of 448 files with the average time being 1.82 seconds (Ntalampiras et al., 2019).

Reflecting on the visualization of the sound recordings in Figure 2, clear distinguishable patterns can be observed among the different classes. In the context of food, the mel-scaled spectrogram (a representation of the frequency spectrum of a signal using a perceptual scale of pitch) indicates that the frequency band is clustered around the middle of the time span (60-80 frames) with the frequency in the temporal modulation visualization being somewhat consistent in modulation but clumped around 2000 Hz in acoustic. During isolation, the mel-scaled spectrogram reflects that the frequency band begins at the 50th frame and tapers out into 3 lines (23, 15, and 10) until the 100th frame. Correspondingly, the temporal modulation graph also shows 3-4 distinguishable horizontal lines around 500, 1000, 2000, and 3000 Hz in acoustic, with a slightly less even distribution along modulation frequency. Finally the brushing spectrogram indicates a very strong frequency band along frames 50-75, with a horizontal cluster along a frequency band of 10 until the 300th frame. The temporal modulation is very evenly distributed, with a slight clump along the 500 acoustic frequency from the modulation frequency -50 to 50 Hz. These unique frameworks therefore symbolize that meowing is not random, but rather conveys emotions and messages. Furthermore, the contexts tested are all human induced (cats do not experience 'waiting for food', 'isolation from owners', or 'brushing' in the wild), proving that cats have specifically tailored

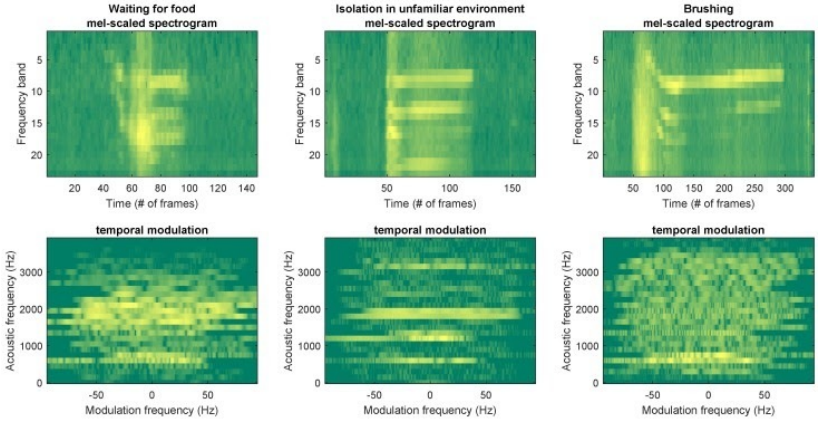
their vocal language in response to a human environment.
Through the utilization of statistical pattern classification techniques, audio signal processing, and pattern recognition algorithms, an AI framework was developed to categorize sample recordings into one of the three given scenarios. Directed Acyclic Graphs (DAG) were used along with hidden Markov models (HMM) rather than a deep learning algorithm in order to provide higher interpretability along with a more comprehensive scheme generalizing the decision tree. The DAG-HMM model had an accuracy rate of 95.94 percent, with 100 percent accuracy in identifying the wait for food, 95.24 percent accuracy in brushing, and 92.59 percent accuracy for isolation (Ntalampiras et al., 2019). The overall success of the AI in labelling the sound recordings with their associated meanings signifies the potential to derive broader interpretations of the cat language in the near future.

Prospects of Cat Translators

The former Alexa engineer Javier Sanchez (now the technical program manager of Akvelon) is revolutionizing the world with his cat translator app, MeowTalk. This app runs on two models, one being the Google data science model that recognizes a cat's vocalization and the other being a more specific system designed for each unique cat audio class (Schlossers, 2020). Since cats customize their meow in accordance to their owners, the application utilizes separate profiles rather than a shared generic database to improve the translations individualized for each cat over time. Currently the app has 13 in-built translations including: "feed me", "I'm angry", "Mommy", and more (Criddle, 2020). Users can also create new labels to assign recordings to, improving the prediction accuracy as it familiarizes itself with the individual cat-specific model (Schlosser, 2020). However, this approach is not without its risks. Since the app is dependent on user input, there is a risk of miscommunication in the owner's own inaccurate interpretation of a cat's vocalization. With the awareness of these possibilities, users should accept translations with a grain of salt until this promising software is able to achieve higher levels of precision. MeowTalk's ideal finished product is the creation of a smart-collar that translates a meow into audible human speech.

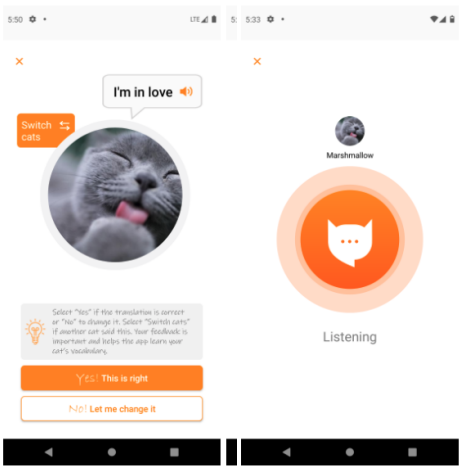
Conclusion

Across history and especially in today's pandemic context, domesticated cats remain close companions with the human population. These fluffballs have clearly captured humanity's heart, whether it be by the infinite number of cat videos recommended by the YouTube algorithm or the warmth and comfort provided by their close contact. As cats have adapted to understand the nuances of human nature both in action and words, the advancements of technology now give us the potential to comprehend their own world, 'pawing' our way forward in the realm of cat communication.



Representations of the meows associated with the three classes (food, isolation, brushing) using Mel-scaled spectrograms and temporal modulation.

Source: *PubMed* (Ntalampiras et al., 2019)

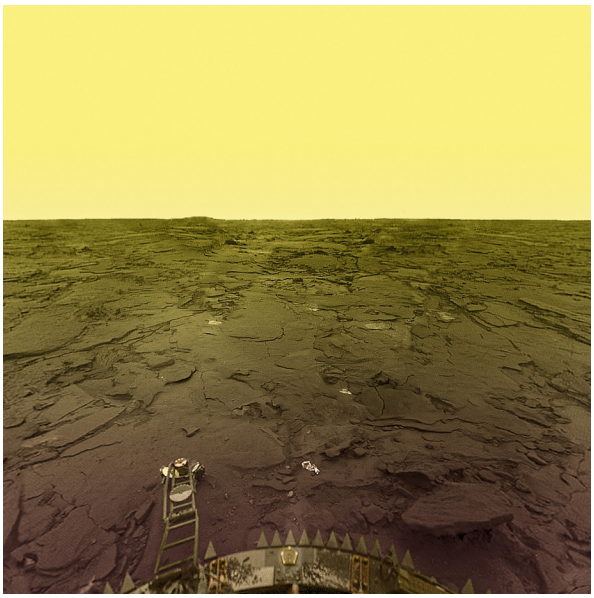


The different screens of the MeowTalk application.

Source: *GeekWire* (Schlosser, 2020)

THE VENUSIAN SKY CITIES OF OUR FUTURE

By Laya Gopalakrishnan



Venus's surface is far from habitable, with its pressure-cooker-like atmosphere and high temperatures.

Source: *Mental Landscape*

Surfacism: an ideology detailing human nature's affinity towards physically colonizing or marking land to claim and inhabit it. Though "surfacism" is not a legitimate word included in any existing dictionaries, according to Dr. Gabe Perez-Giz, former host of "PBS Space Time," it is still a prevalent issue, most notably in the field of space exploration and habitation. In recent years, space scientists have looked towards colonizing the surface of Mars, yet many jarring flaws lie in this plan. Not only does Mars have a thin atmosphere, making the planet more susceptible to radiation from the sun, but its gravitational force is around 37.5% of that of Earth's. Still, humanity's long established obsession with "planting the flag" so to speak, has led to Mars being considered the perfect planet. Now, the question may arise: if not Mars, what is the ideal planet for colonization? Well the answer lies quite literally closer than one may at first imagine: our sister planet, Venus! Or rather, Venus's dense, upper atmosphere. Venus's upper atmosphere provides near Earth-like conditions and is dense enough, possibly allowing for floating habitats to populate the barren Venusian skies.

Location, Location, Location!

Venus's surface is nothing short of hellish. Acid rain composed of sulphuric acid torments the planet's volcanic surface. With temperatures reaching up to 480°C (900°F)—hot enough to melt lead—and a surface pressure ninety-five times that of Earth's, it is no wonder why many may be quick to dismiss the idea of colonizing Venus's surface. The constant threats of corrosive high-pressure carbon-dioxide, molten rock, and lava flow, create an ever changing, unlivable, grim landscape, a stark difference from life above the clouds.

The Venusian atmosphere can be split up into four parts: the upper atmosphere, middle atmosphere, main cloud layers, and lower atmosphere. The **upper atmosphere** contains the outermost portion of the Venusian skies, extending outward to the fringes of the planet's atmosphere. It is the coolest part of the planet, reaching around 27 - 37°C at its warmest and less than -173°C at its coldest. From here, the temperature steadily increases to around -100°C at the 100 km mark. This altitude marks the end of the upper atmosphere and the beginning of the **middle atmosphere**. The middle atmosphere extends downwards from the 100 km mark to just above the continuous cloud deck.

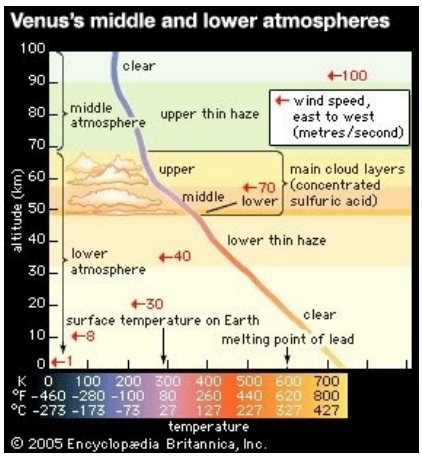
From 50 km to 70 km begin the **main cloud layers**, composed of large, quick-moving clouds of sulfuric acid, high winds, and acid rain. Radio waves, hinting at the existence of lightning and thunderstorms, have been observed in the Venusian cloud layers. This paired with the variance in cloud tenuity suggests a meteorologically active upper cloud layer. The lower half of Venus's cloud layer provides near perfect conditions for human habitation. Here, temperatures reach around 70oC (158oF) and pressure, about 1 atm, similar to being 34 feet under water. Heat resistant clothing—similar to firefighter garments that can withstand up to 2000oC (3632oF)—and oxygen tanks can create quick fixes to these issues.

Finally, the **lower atmosphere,** extending downwards from around 50 km above Venus's surface. It is a common misconception that Venus absorbs a large amount of light from the Sun, and, as a result, is one of the hottest planets in the solar system. In reality, the Venusian atmosphere reflects a large portion of the sunlight it comes into contact with, and is partly to thank for it's intense "glow". The planet's thick cloud layer reflects about 70% of the sunlight that reaches it, back into space. Using the albedo light measurement scale - which quantifies the proportion of sunlight a planet reflects versus what it receives - scientists have capped Venus at an albedo of 0.77, compared to Mars's 0.25. What little sunlight that does reach the planet's surface is trapped there due to an intense greenhouse effect. Therefore, choosing a density sweet-spot in the Venusian atmosphere proves to be much easier than the now popularized idea of creating a thicker atmosphere on Mars.

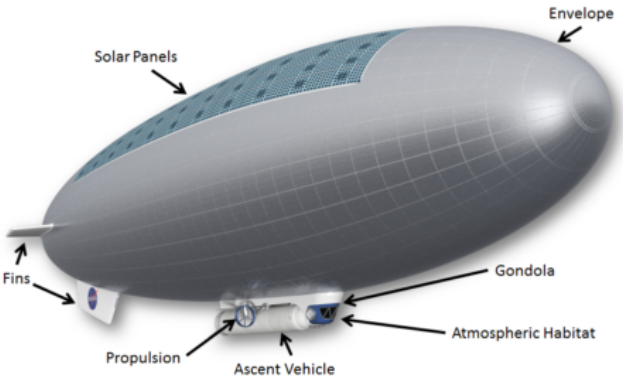
Despite the Venusian atmosphere being the planet's most prevalent and diverse feature, surfacism continues to look past the great potential that living among the stars has to offer. Though the ideology can be excused to some degree considering that human's relation to air travel is just that, temporary transit, living on the surface of many of the planets in our solar system is an unrealistic expectation. Therefore it is of utmost importance that we broaden our scope of expected locals for habitable planetary locations, looking beyond—or above—surfacism.

HAVOC! in the Atmosphere

The idea of colonizing Venus gained short-lived popularity with NASA. The High Altitude Venus Operational Concept, a now inactive project, sought to develop the mission architecture and vehicle concept for a 30 day crewed mission into Venus's atmosphere," - NASA Systems Analysis and Concepts Directorate. In this mission, two separate airships would be used: one to transport the crew, and one to transport the blimp-like LTA (lighter-than-air) airship, for crew habitation.



The Venusian atmosphere can be split up into four parts: the upper atmosphere, middle atmosphere, main cloud layers, and lower atmosphere. Source: *Encyclopædia Britannica*



The LTA itself would be fitted with various "bells and whistles", so to speak.

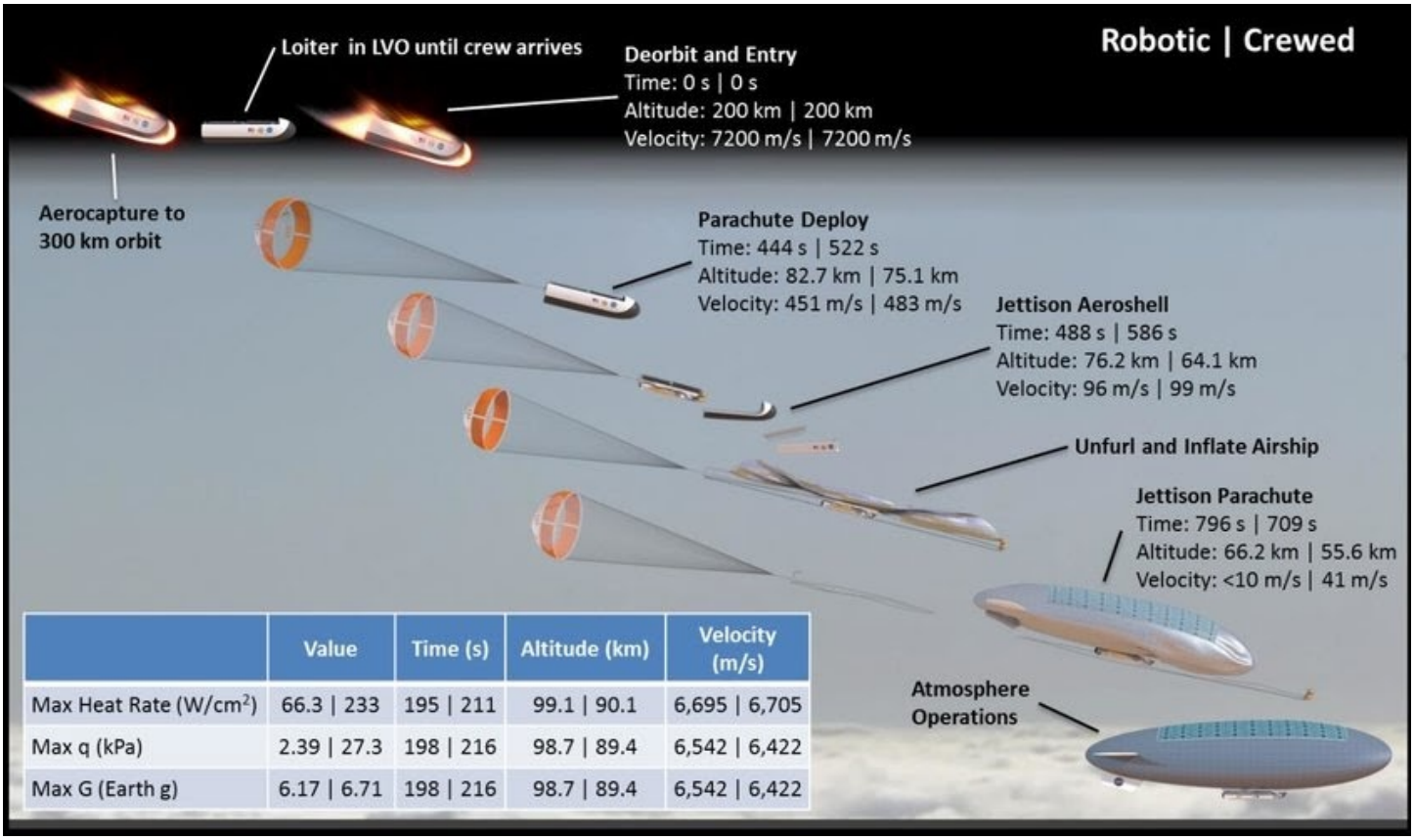
Source: *NASA Technical Reports Server*

The LTA airship would travel at a higher speed, loitering in LVO (Lower Venusian Orbit) until the manned airship arrived. Then, two airships would connect, crew would be transported into the LTA airship, and the LTA airship would descend into the Venusian atmosphere, shedding any unnecessary protection once at the target 50 km range, and unfurling into a blimp. It is important to note that the blimp itself is not a habitat, merely a flotation device for the crew quarters. Attached to the LTA will be various robots and rovers that will deploy onto the Venusian surface for observational purposes. It may be possible in the distant future to bring back samples, but this would mean creating robots strong enough to travel through the Venusian atmosphere, onto it's treacherous surface, and back, unscathed. Additionally, the possibility of contaminating the crew quarters with Venusian surface debris or gasses in the Venusian atmosphere pose great risks.

After a successful mission, the ascent vehicle containing the crew quarters would detach from the LTA, and fly up toward the original crew airship, which has since remained in LVO. The crew quarters will detach from the ascent vehicle and attach to the crew airship, which will then begin it's travel back towards Earth. The LTA and ascent vehicle will remain on Venus and be destroyed upon reaching the planet's surface.

Conclusion

Space colonization is inevitable. Though launching a manned mission to Venus will likely occur far after any Mars missions, if at all, the exploration of planets other than our own will remain a goal of space scientists to come. The colonization of any planet, regardless of surfacism bias, will be a groundbreaking moment for humanity. And who is to say? The exploration and colonization of planets within our solar system may, eventually, lead to manned travel beyond our patch of the universe, delving deeper into our galaxy and beyond.



HAVOC decent mission architecture

Source: *[NASA Technical Reports Server]*

THE OVERLOOKED LABOR OF TREE PLANTERS

By Erin Yoo

By now, most people have heard of ambitious goals in reforesting the planet. Perhaps the most famous of these efforts is the Trillion Trees Initiative, which was a global attempt to restore and plant not one million, not one billion, but *one trillion* trees by 2050 ("Forests are," n.d.). Countries have supported and contributed to this initiative, like New Zealand which is currently on its way to plant one billion trees by 2028 (Ministry for Primary Industries, n.d.; Steffen, 2019). The Trillion Trees Initiative was even supported by former U.S. President Donald Trump, whose administration was infamous for prioritizing the economy over Earth throughout his presidency (Rudee, 2020). After much protesting and pushing for governments to take climate action, notably by youth, it can be relieving to see that many governments are committing to this environmentally conscious goal.

But, addressing the climate crisis is not just helpful for appeasing activists. Not only do trees suck out carbon and other greenhouse gases in the atmosphere, they also help address human health problems. For example, trees filter the air, decreasing rates and intensity of respiratory disease stemming from air pollution (Rudee). Trees can also provide economic benefits, as tree planting initiatives provide sustainable employment for thousands. Reports also show how trees increase prices of houses and other commodities, which consumers are willing to pay for ("How Trees," n.d.). In short, trees deserve all the praise and credit they receive. But, how will the world reach the one trillion tree finish line? Who will put in the work? The answer lies in tree planters. Often overlooked, tree planters are those who dedicate their time to reforestation.

"The two reasons why I keep coming back to planting are the endorphins it gives you, and the other one for sure is the money."

Source: [*One Tree Planted*]

A Brief Job Description

Much physical and psychological strength is needed to persevere in this job, so many new planters actually quit in the beginning. Surprisingly, many consider the mental fortitude required in tree planters more important than the physical capabilities. As one tree planter in Quebec stated, "I think, personally, planting is maybe 30% physical. But it's 70% psychological" (One Tree Planted, 2020). Planters must be able to wake up early each morning and face the day knowing what monotonous, strenuous work is ahead. Since the work is usually done individually, planters are kept company by their thoughts throughout the entire work day, which is understandably mentally draining ("Discover," n.d.).

Despite — or perhaps due to — the vigorous labor, the work pays

well (planters are paid by the number of trees they plant). On average, planters can earn $90 USD per day, but veteran planters can earn $169 USD each work day ("Discover," n.d.). Plus, living and travel costs are paid for them ("Discover," n.d.). This may come as no surprise due to the importance of the work. The same Quebec planter from above admitted, "The two reasons why I keep coming back to planting are the endorphins it gives you, and the other one for sure is the money" as seen in Figure 1 (One Tree Planted, 2020). This also makes tree planting an alluring summer job option for students ("The 5 Best," n.d.).

The general minimum education requirement to hold this position is a high school diploma. However, those with extra forestry education and or experience may find more opportunities in tree planting ("At a Glance," n.d.). Those with a few extra years under their belt may also supervise other planters in the field ("At a Glance," n.d.). Another career area in tree planting is to become a forest manager, the person responsible for managing minute logistical details of planting. Forest managers must become intimately familiar with the numbers of tree planting operations each day: how many trees must be planted per unit area, how many trees must be planted per planter, distance needed between each planter, and more (RNZ, 2019).

A Day in the Life of a Tree Planter

Waking up in the early hours of the morning around 5am, tree planters often work individually in remote, rough terrain in grid formation (One Tree Planted, 2020; RNZ, 2019). The work is more arduous and demanding than it may seem; planters carry heavy boxes of seedlings on their hips and backs and shovel the dense earth. The earth is likely filled with dead logs and other brush, as seen in Figure 2, so planters have to constantly dodge and maneuver their steps while carrying the burden of twenty kilograms on their torso ("Discover," n.d.). Environmental conditions like bugs and weather can also take a toll on planters.

Experienced tree planters can plant up to 1,200 trees per day, going back and forth to the truck with materials multiple times to get more seedling boxes (RNZ, 2019). As Lisa Owen, a news correspondent in New Zealand, realized, much of the planting work has to be done with the feet because using your hands may cause back problems as you bend over. Other tasks during the planting day may entail unloading seedlings from trucks, watering and spraying seedlings, and moving trees from one location to another.

A tree planter at work.

Source: [*The Environmentor*]

The day ends relatively early, and some planters can work as little as five hours each day ("Discover," n.d.). By mid-afternoon, around 3 PM, most trees have been planted and the planters get to rest while heading back to their base camp. Back at camp, where planters usually live with dozens or a hundred other coworkers, planters may have to perform camp duties like washing the dishes ("At a Glance," n.d.). In the evening, clothes, equipment, and food must be prepared for the next day, which will start early again. Overall, the majority of non-planting time is spent traveling, cleaning, and preparing, so free time is scarce.

Conclusion

In order for the world to meet its united goal of planting vast amounts of trees, countries must rely on the labor of volunteers, environmental organizations, and especially tree planters. These extraordinary individuals have already made stunning progress in the past few years. In New Zealand, tree planting projects have resulted in 259 million trees planted in two years as of January 2021, or 26% of the billion tree goal (Ministry for Primary Industries, n.d.). At this rate, New Zealand will be able to successfully plant one billion trees in the next decade.

In 2020 alone, China, India, Ethiopia, Pakistan, and Mexico collectively planted approximately eight billion trees, making them the top five countries to plant the largest amount of trees that year (Stanton 2020). With these numbers, ambitious tree reforestation projects seem more and more likely to be successful in the end. Through their early mornings, mental discipline, and unwavering loyalty to the environment, tree planters have done the dirty work that often goes unmentioned in conversations of reforestation.

Complete sources and citations are
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